RANGER

WORKSHOP ON BORDER SECURITY
RELATED EU FUNDED PROJECTS

RANGER
Project Overview

DIMITRIS KANAKIDIS, EXUS

Horizon 2020
European Union funding
for Research & Innovation

Outline

- RANGER ID
- Consortium
- Objectives
- RANGER concept & pilots
- RANGER vision & impact

Horizon 2020
European Union funding
for Research & Innovation

RANGER at a glance

- BES-01-2015: Radar systems for the surveillance of coastal and pre-frontier areas and in support of search and rescue operations
- "RANGER: RAdars for loNG distance maritime surveillancE and Search and Rescue opeRations"
- Grant agreement no: 700478

- Start date: 1 May 2016
- End date: 31 October 2019

- Total budget: 7,992,312.50 €
- Total funding: 7,992,312.50 €

Horizon 2020
European Union funding
for Research & Innovation

Introducing Ourselves

- 10 partners
- 7 countries
- 4 pilots
- 42 months

Horizon 2020
European Union funding
for Research & Innovation

Introducing Ourselves

No	Participant organisation name	Type	Country
	Technology providers		
1	EXUS Software Ltd (EXUS)	SME	UK
2	DIGINEXT (DXT)	IND	FR
3	Institute of Communications and Computer Systems (ICCS)	RTO	GR
4	Technische Universitaet Dresden (TUD)	RTO	DE
5	Laurea University of Applied Sciences (LAU)	RTO	FI
6	FINMECCANICA (FNM)	IND	IT
7	TELESTO Technologies (TEL)	SME	GR
8	NATO CMRE (NATO)	RTO	BE
	Partner End-users		
9	Ministry of Defence (HMOD)	END USER	GR
10	Directorate of Maritime Affairs (DMA)	END USER	FR
	Supporting End-users		
A	Italian Marina Militare	END USER	IT
B	European Coast Guard Functions Forum	END USER	BE
C	Direction générale des douane et des droits indirects	END USER	FR

Horizon 2020
European Union funding
for Research & Innovation

RANGER Objectives 1/6

RANGER innovates by combining **novel and ground-breaking Radar technologies** with innovative supporting technological solutions for **early warning**, in view of delivering a **surveillance platform** that will offer detection, recognition, and identification as well as tracking of suspicious vessels capabilities far beyond existing legacy radar systems, seamlessly fitting and contributing to the CISE framework through the provision of on-demand **CISE compliant services**.

Horizon 2020
European Union funding
for Research & Innovation

RANGER Objectives 2/6

- **High-level Objective 1:** To provide a complete solution for traffic surveillance and search and rescue operations offering **vessel detection, recognition,** and **identification** capacities far beyond existing radars in terms of both target size and range for traffic surveillance and search and rescue operations
  - improving the detection range for smaller boats of the new Stradivarius Over-The-Horizon (OTH) Radar system
  - design and develop a novel Photonically Enhanced MIMO Radar configuration that will increase resolution and detectable target speed by order of magnitude
  - To design and develop a novel Early Warning System (EWS) that exploits deep and adaptable machine learning schemes able to Automatically Detect radar Targets

Horizon 2020
European Union funding
for Research & Innovation

RANGER Objectives 3/6

- **<u>High-level Objective 2:</u>** To **lower the total cost of ownership** (acquisition, installation, operation and maintenance) compared to existing radar solutions
  - To evaluate the benefits of trade-off on system design (e.g. use of a carrier frequency close to 9 MHz, use of new antenna array layout or antenna shape), in order to reduce antenna array size, antenna's number, and transmitted power
  - design radar systems with individual performances equivalent or superior to those obtained by using multiple legacy radar systems, resulting as such to cost effective solutions

Horizon 2020
European Union funding
for Research & Innovation

RANGER Objectives 4/6

- **<u>High-level Objective 3:</u>** To ensure **compatibility of the RANGER platform with CISE**, already from the design phase in order to safeguard seamless interoperability in line with the CISE compliance framework through a scalable set of CISE-ready RANGER services
  - Incorporate information with regard to the CISE framework from the design and architectural phase of the RANGER platform through close interaction loops, basically with EUCISE 2020 project
  - Develop a CISE translation gateway as an aggregator of interfaces that will allow the RANGER services to operate in a CISE compliant framework
  - Develop at least three CISE compliant RANGER services (the OTH Radar tracks, PE-MIMO Radar tracks, and Early Warning System) validated in a cross-country demonstration environment.

Horizon 2020
European Union funding
for Research & Innovation

RANGER Objectives 5/6

- **<u>High-level Objective 4:</u>** To **validate** and **demonstrate** the effectiveness of the **integrated RANGER** platform in **relevant environments** by the actual public authorities/end-users in **two terrain-diverse operational scenarios** that will be implemented in two phases each, accomplishing at the end of the project a TRL-6 level for the entire RANGER platform.
  - To validate the integrated RANGER platform (in 2 phases) by the public authorities/ end-users in both Greece and France in conjunction with Italian Marina Militare (Italian Navy)

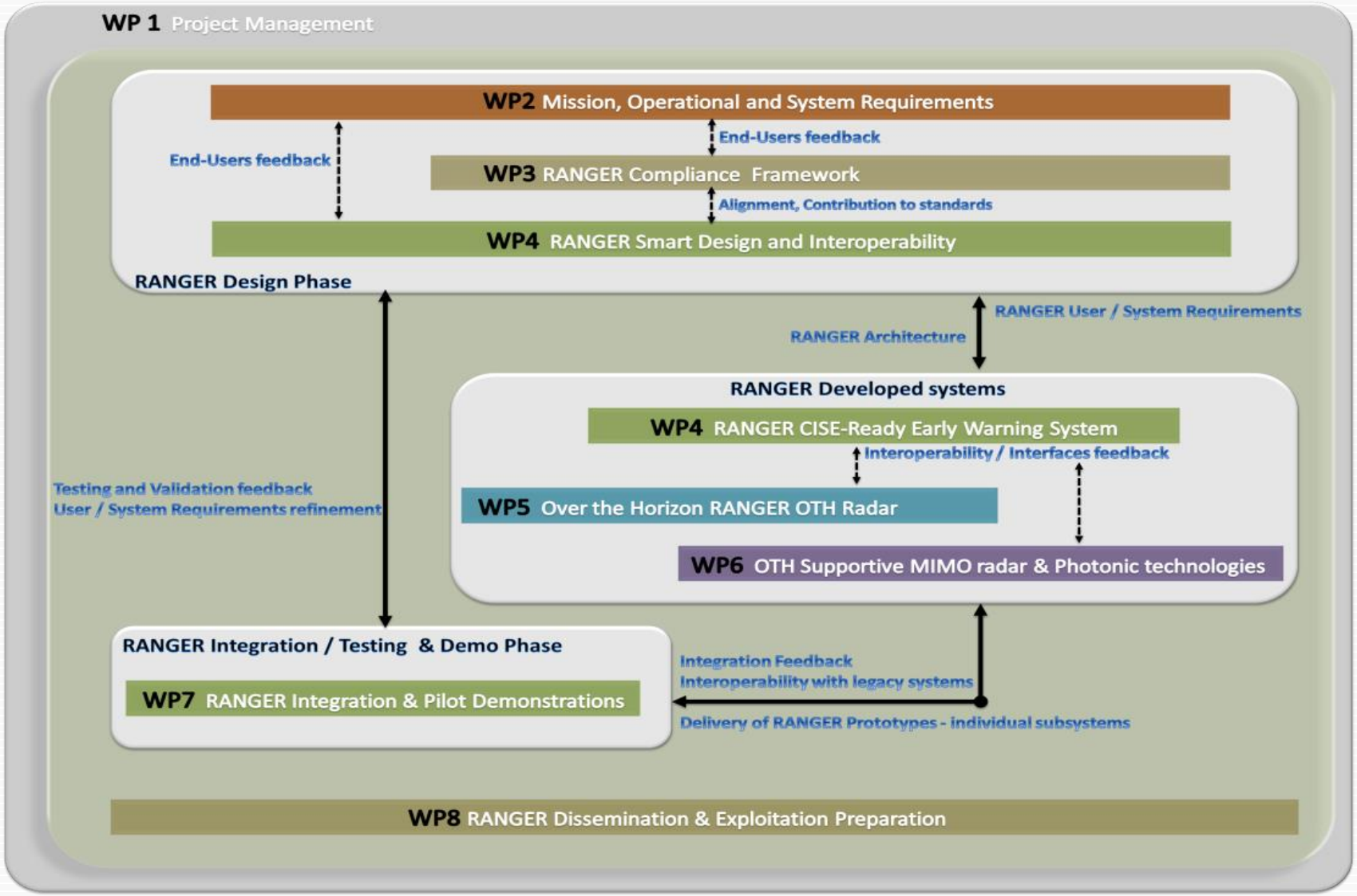
Horizon 2020
European Union funding
for Research & Innovation

RANGER Objectives 6/6

- **<u>High-level Objective 5:</u>**To define a **multilevel compliance framework** that RANGER solution will be aligned with.
  - To define Societal/Ethical/Legal constraints and establish the procedures that are needed to comply with current ethical, societal and legal frameworks
  - To smoothly integrate with landscape, while minimizing the environmental footprint
  - To gather currently used procedures, best practices and technical standards that should be followed during development phase to ensure system compatibility and interoperability with legacy systems
  - To be aligned with CISE/EUROSUR roadmaps
  - To analyse Drug Trafficking and Irregular Immigration trends and practices to gain knowledge and understanding of trafficking and irregular immigration in order to clarify the behaviour of the maritime surveillance targets

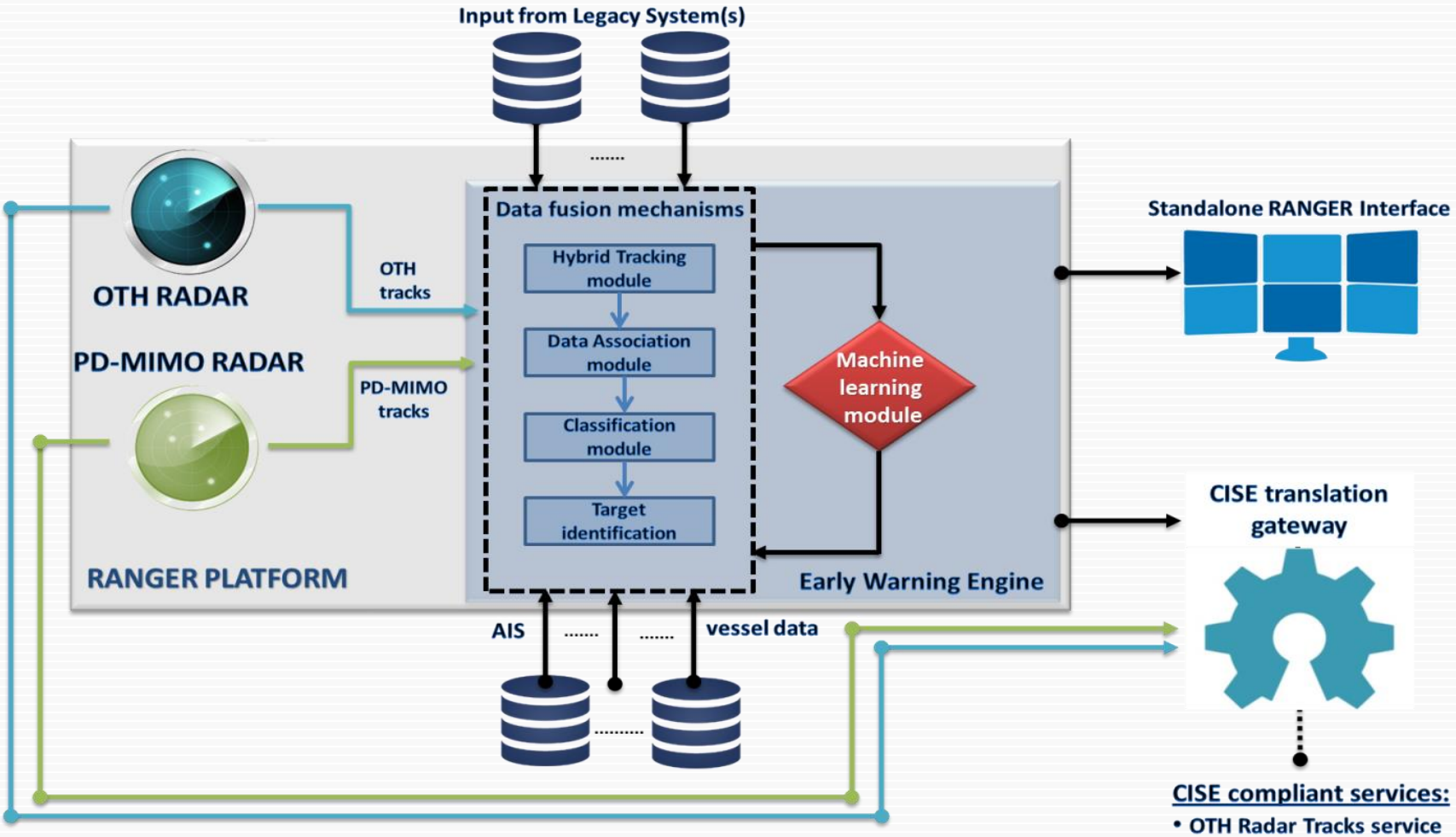
Horizon 2020
European Union funding
for Research & Innovation

How? – Pert Diagram



Horizon 2020
European Union funding
for Research & Innovation

RANGER Technical Concept



CISE compliant services:

- OTH Radar Tracks service
- PD-MIMO Radar Tracks service
- RANGER EWS service

Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **RANGER Over-The-Horizon Radar**

Stradivarius coverage vs current maritime surveillance radars

First Stradivarius prototype (site in Camargue Natural Park)

Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **RANGER Over-The-Horizon Radar**

OTH Stradivarius

above 25m long

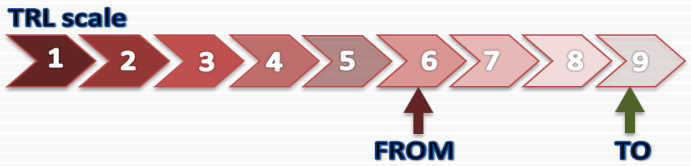
up to 200Nm

OTH Ranger

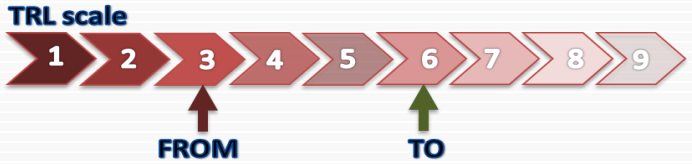
down to 2m ASL

up to 150Nm

(ASL = above sea level)



RANGER OTH Radar detecting >25m long ships up to 200Nm from coastline (sea state 3)



RANGER OTH Radar detecting <12m long ships up to 150Nm from coastline (sea state 3)

Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

RANGER Over-The-Horizon Radar

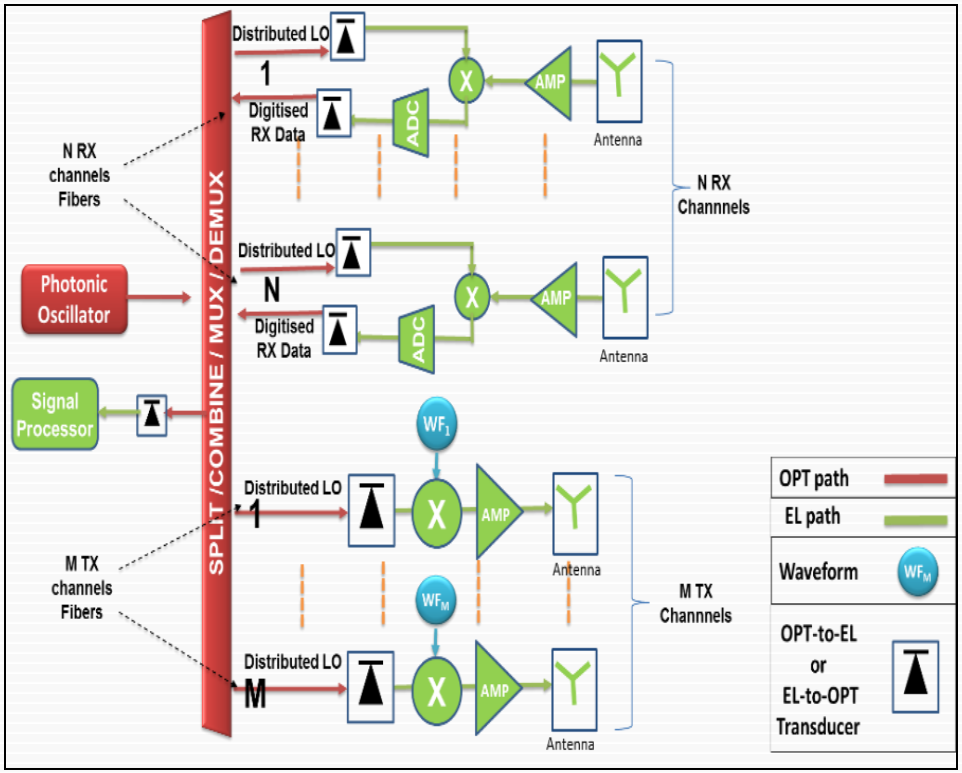
- **Capabilities :**
  - High range detection radar (150 to 200 Nm)
  - Continuous detection on the area of interest
  - Limited power : between 400 W and 2 kW
  - Limited environmental footprint

- **Foreseen performance :**
  - Impacted by
    - Sites characteristics
    - antenna array size,
    - Frequency availability ,signal bandwidth, interference and site EM noise…
  - Target accuracy for the full-featured system:
    - Linked with antenna pattern and bandwidth,
    - helped by hyper-resolution algorithm
    - Azimut : ± 0.2°
    - Range : ± 100m
  - Detection rate vs false positive :
    - Detection : 99%
    - Deep machine learning techniques for Automatic Target Recognition and correlation with existing AIS and LRIT will minimize false positives in the tracking capabilities of RANGER system.

Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **RANGER Photonics-Enhanced MIMO Radar**



A possible architecture for a PE-MIMO.

- Detection of small and fast maneuvering vessels
- Extremely high resolution and very frequent scanning refresh cycles

Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **RANGER Photonics-Enhanced MIMO Radar**

Core advantages: MIMO technology vs Standard Phased Array:

- Highly increased aperture size and resolution
- Increased probability of detection due to suppression of the Radar Cross Section (RCS) fluctuation problem
- Increased probability of detection due to higher SNR
- Number of targets detectable increased Mt times

Core advantages: PE-MIMO technology vs MIMO:

- Increase detection range due to photonic oscillators with minimum phase noise
- Massively increased aperture size due to additional transmit arrays
- By order of magnitude increased probability of detection due to strongly increased suppression of RCS fluctuation problem
- Further increased probability of detection due to higher SNR
- Enhanced spatial resolution due to usage of distributed antenna arrays
- By order of magnitude increased number of targets detectable

Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **RANGER Early Warning System (EWS)**

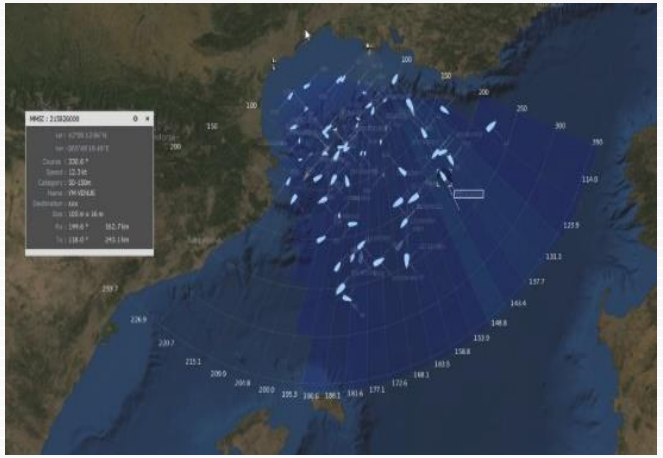
EWS will be built upon **advanced Data fusion** algorithms and architectures as well as **novel deep machine learning** structures to provide:

- A **threat classification** of all simultaneously detected targets based on AIS data, historical data in available databases as well as maneuvering patterns of detected and tracked vessels.
- **Automatic Target Recognition** (ATR) through cross correlation of Radar and AIS data.
- **Target Continuous Tracking**, especially valuable for high-threat vessels.
- **Alarms** including collision warning, boundary violation and proximity alerts.
- **Recommendations on required interventions** based on risk assessment and self-training of threat detection models.

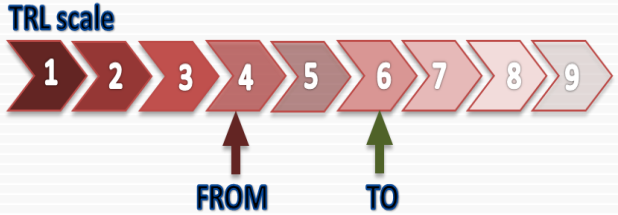
Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **RANGER Advanced User Interface**



Left: An example of an adaptive multimodal interface developed in DXT's INDIGO project for crisis management using a tactile surface and tangible interactive objects. Center: a physical ruler in placed on the table to define a zone and display the scale. Right: An example of a maritime surveillance interface developed with VirtualGeo.



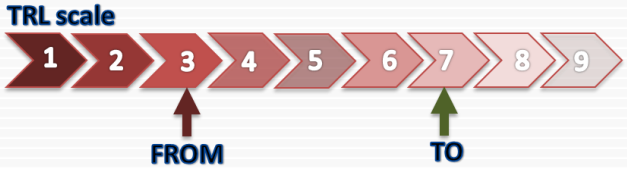
Horizon 2020
European Union funding
for Research & Innovation

RANGER Technologies

- **CISE translation Gateway**

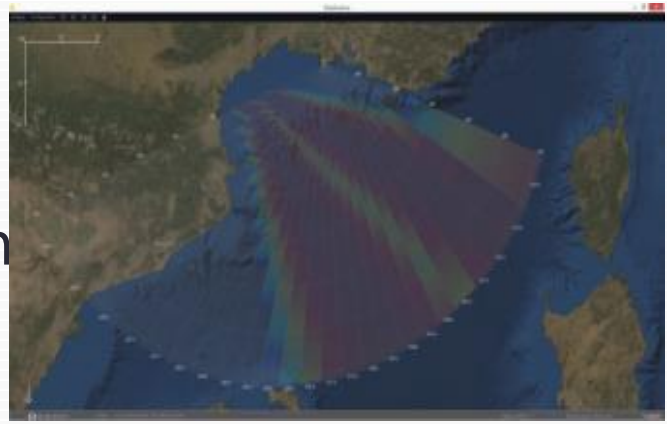
The CISE translation gateway is a layer that:

- will **serve as the connecting link** between the RANGER architecture's resources (RANGER platform and RANGER sensors) and the framework which implements the CISE concepts.
- will **serve as an aggregator of interfaces** that is responsible for receiving and collecting data from the field sensors (OTH, MIMO radar) as well as retrieving resources from the overall RANGER framework
- collectively translates the resources (data and metadata) into a **unified format that is CISE compliant** so that it is forwarded to the upper layer of CISE architecture (i.e. services) using a common CISE model.



Horizon 2020
European Union funding
for Research & Innovation

How? - RANGER Validation Pilots

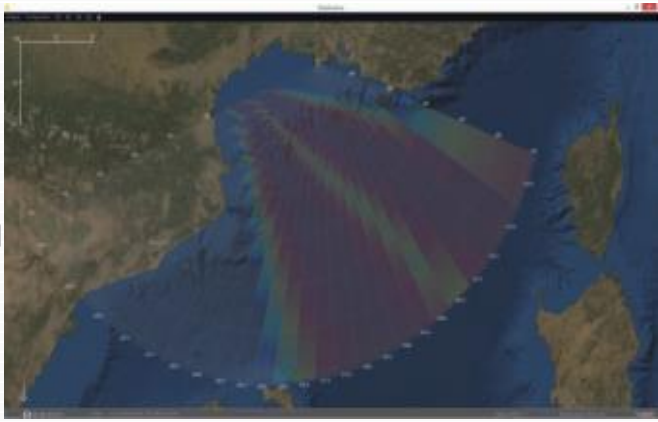


- **<u>Pilot Case 1:</u>** Cross-country collaboration to confront drug trafficking and/or irregular immigration incidents in between French and Italian waters.

- **<u>Challenges:</u>**
  - Detect /track /identify non cooperative vessels travelling from South Mediterranean (Balearic Islands) towards Central Mediterranean and French/Italian shorelines.
  - Classify these vessels according to their threat level, based on cross-correlation and analysis of data originating from various sources (OTH Radar, PE-MIMO Radar, AIS, ATR using deep learning algorithms)
  - Get an early warning capability on Lion Gulf
  - Sharing of information between **French / Italian Authorities**
  - Fusion of real-time updated information to enhance situation awareness and efficient cooperation among neighbouring countries.

Horizon 2020
European Union funding
for Research & Innovation

How? - RANGER Validation Pilots



- **Pilot Case 1:** Cross-country collaboration to confront drug trafficking and/or irregular immigration incidents in between French and Italian waters.
- **Validation and Metrics (indicative):**
  - Fully operational RANGER OTH RADAR installed on French shorelines
  - Fully operational RANGER PE-MIMO Radar
  - Fully functional RANGER EWS with AIS data depiction and CISE Gateway integrated
  - DMA's surveillance system picture on Mediterranean sea
  - Italian Navy Maritime Situational Awareness C2 Environment (unclassified part only) operated by FNM and IT Navy MSA operator

Horizon 2020
European Union funding
for Research & Innovation

How? - RANGER Validation Pilots

- **Pilot Case 2:** Cross country collaboration to face irregular immigration case that turns into a sea Search and Rescue Operation in Greek Archipelago and in between Italian/Greek waters

Scenario with OTHR in Karpathos –Kasos complex

Scenario with OTHR in Aktio - Preveza complex

Horizon 2020
European Union funding
for Research & Innovation

How? - RANGER Validation Pilots

- **Pilot Case 2:** Cross country collaboration to face irregular immigration case that turns into a sea Search and Rescue Operation in Greek Archipelago and in between Italian/Greek waters
- **Challenges:**
  - Detect /track /identify non cooperative vessels travelling from Eastern Mediterranean (Greek coastlines) towards Central Mediterranean and Italian shorelines.
  - Classify these vessels according to their threat level, based on cross-correlation and analysis of data originating from various sources (OTH Radar, PE-MIMO Radar, AIS, ATR using deep learning algorithms)
  - Get an early warning capability before entering the Italian National waters
  - Exchange of information in real time between **Italian / Greek Authorities**
  - Fusion of real-time updated information to enhance situation awareness among neighbouring countries

Horizon 2020
European Union funding
for Research & Innovation

How? - RANGER Validation Pilots

- **Pilot Case 2:** Cross country collaboration to face irregular immigration case that turns into a sea Search and Rescue Operation in Greek Archipelago and in between Italian/Greek waters
- **Validation and Metrics (indicative):**
  - Maximum OTH Radar range vs transmitted power and frequency used
  - Detection and tracking vessels capabilities vs targets size (Radar cross section) and features (sailing boat, trawlers, fast boat, etc)
  - AIS data depiction and number of unreported vessels detected
  - PE-MIMO Radar close range targets separation capabilities
  - Sea and ionospheric clutter mitigation
  - Tracked non cooperative vessels rate vs AIS situation
  - Identification capabilities and threat classification
  - ARPA (Automatic Radar Plotting Aid) capability
  - Collaboration (data exchange) with Electronic Chart Display & Information System (ECDIS)

Horizon 2020
European Union funding
for Research & Innovation

End Users Expectations

Gaps

- Traditional methods (VHF, radars) → lack of accuracy and time delays
- Illegal actions with small vessels:
  - Difficult to be detected
  - Abandoned or sank
  - Loss of lives

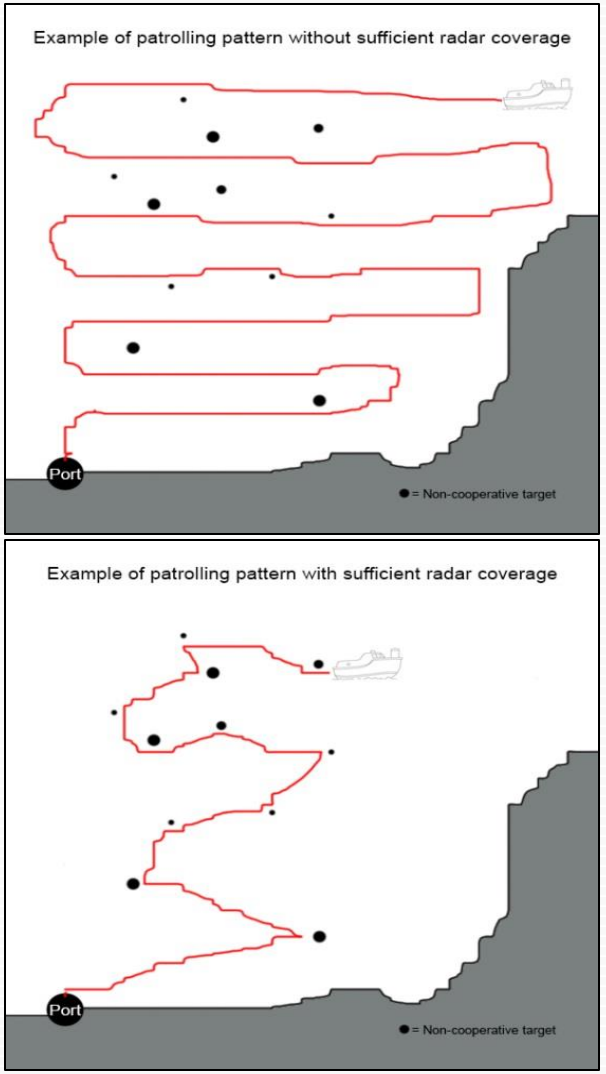
Expectations

- Complete solution
  - Improve the detection range with the OTH radar
  - Improve the performance of existing radars with MIMO technology
  - Design and develop a novel Early Warning System
- Lower the cost of ownership
- Compatibility between RANGER platform and CISE
- Close co-operation between end-users- research institutes-industry

Horizon 2020
European Union funding
for Research & Innovation

RANGER Impact

- **Research and Innovation impact**
  - OTH Radar
  - PE-MIMO Radar
  - Deep Machine Learning
- **Impact on Maritime Surveillance and Operations**
- **Impact on Search and Rescue (SaR) operations**
  - Early detection of vessels with unusual behaviour allowing interventions to occur before any incident occurs
  - Optimization of end-user resources under SaR Operations
  - Efficient coordination of SaR Operations
- **Impact on Irregular Immigration prevention**
  - a fully automated and self-learning platform
  - generate early warnings and detection alerts of "potentially suspicious" vessels



Patrolling pattern examples

Horizon 2020
European Union funding
for Research & Innovation

RANGER Impact

- **Impact on Illegal actions confrontation**
  - Re-enforce EUROSUR, FRONTEX
  - Comply with the CISE environment
  - Generates a common situational picture, improved detection and on-time identification of non-collaborative/suspicious small boats
  - Support enhanced and increasingly automated detection of abnormal vessel behaviours
- **Impact on the Maritime Surveillance Market**
- **Environmental impact**
  - Airspace is not affected
  - Land Use does not change
  - Local Wildlife Ecosystems Annoyance is expected to be minimum
  - Small Footprint and visual impact

Installations of the Stradivarius OTH Radar (Tx/Rx stations) in southern France – Courtesy of DXT

Horizon 2020
European Union funding
for Research & Innovation

RANGER

Thank You!

DIMITRIS KANAKIDIS, EXUS
dkan@exus.co.uk

Horizon 2020
European Union funding
for Research & Innovation